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IS 10139 (1982): Presentation of reliability, maintainability and availability predictions [LITD 2: Reliability of Electronic and Electrical Components and Equipment]



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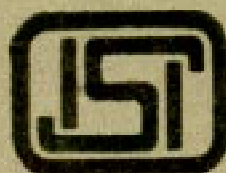
"Reaffirmed 1985"

IS : 10139 - 1982

Indian Standard

PRESENTATION OF RELIABILITY, MAINTAINABILITY AND AVAILABILITY PREDICTIONS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

PRESENTATION OF RELIABILITY, MAINTAINABILITY AND AVAILABILITY PREDICTIONS

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Indian Standard

PRESENTATION OF RELIABILITY, MAINTAINABILITY AND AVAILABILITY PREDICTIONS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 2 March 1982, after the draft finalized by the Reliability of Electronic and Electrical Components and Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 The object of this standard is to provide the writer of a prediction report with a complete listing of all items to be considered in making a proper and full presentation of prediction information. This recommended way of presentation is intended to facilitate comparisons between projects reports.

The purpose of a presentation of information on a prediction is to provide the reader of the report with sufficient information for the evaluation of the prediction results and the principles and means by which these were obtained.

NOTE — A prediction of reliability, maintainability and availability characteristics may generally be seen as a multistage model building. As an example the procedure in Appendix A is given to clarify the principle of presentation of predictions. The procedure itself is not to be considered as a standard.

0.3 In the preparation of this standard, assistance has been derived from the IEC document 56 (Central Office) 80 Draft — Presentation of reliability, maintainability and availability predictions, issued by the International Electrotechnical Commission.

0.4 This standard is one of a series of Indian Standards on reliability of electronic and electrical components and equipment. Other standards published so far in the series are given on the fourth cover page.

1. SCOPE

1.1 This standard defines the items which should be considered for the presentation of information regarding predictions of quantitative

characteristics of reliability, maintainability and availability of systems and equipment including hardware, software and human elements.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions covered in IS : 1885 (Part XXXIX) - 1979* shall apply.

3. CONTENTS OF THE PRESENTATION

3.1 The presentation of information regarding a prediction of reliability and maintainability characteristics shall be given in a report containing the items as stated in Table 1.

The depth of presentation (that is, which and what amount of details to be given) is dependent on the purpose of the prediction. For a specific prediction all procedural steps and conditions given in 4.2 to 4.10 are not necessarily applicable. For example, a pure reliability prediction of a simple apparatus may proceed without any relation to maintenance.

TABLE 1 REQUIRED INFORMATION

INFORMATION	CLAUSE REFER- ENCE	PREDICTED CHARACTERISTICS			
		Reliability		Main- tain- ability	Avail- ability
		Maintained items with redun- dancy	Other items		
(1)	(2)	(3)	(4)	(5)	(6)
Summary	4.1	R	R	R	R
Prediction purpose	4.2	R	R	R	R
Prediction object	4.3	R	R	R	R
Characteristics	4.4	R	R	R	R
Initial conditions:	4.5				
System/equipment functions	4.5.1	R	R	CR	R
Failure definitions	4.5.2	R	R	CR	R
Quality/reliability programme	4.5.3	R	R	NA	R
Environmental conditions	4.5.4	R	R	CR	R
Operational conditions	4.5.5	R	R	NA	R

(Continued)

*Electrotechnical vocabulary: Part XXXIX Reliability of electronic and electrical items (first revision).

TABLE 1 REQUIRED INFORMATION — *Contd*

INFORMATION	CLAUSE REFER- ENCE	PREDICTED CHARACTERISTICS			
		Reliability		Main- tain- ability	Avail- ability
		Maintained items with redun- dancy	Other items		
(1)	(2)	(3)	(4)	(5)	(6)
Definition of maintenance actions	4.5.6	R	NA	R	R
Preventive maintenance conditions	4.5.7	R	R	R	R
Corrective maintenance conditions	4.5.8	R	NA	R	R
Maintenance support conditions	4.5.9	R	NA	CR	R
Analysis:	4.6				
Reliability structure analysis	4.6.1	R	R	CR	R
Stress analysis	4.6.2	R	R	NA	R
Maintainability analysis	4.6.3	R	NA	R	R
Maintenance support analysis	4.6.4	R	NA	CR	R
Models:	4.7				
Reliability:	4.7.1				
Structure model	4.7.1.1	R	R	CR	NA
Model adaptation	4.7.1.2	R	R	NA	NA
Mathematical model	4.7.1.3	R	R	NA	NA
Maintainability:	4.7.2				
Structure model	4.7.2.1	CR	NA	R	NA
Model adaptation	4.7.2.2	NA	NA	R	NA
Mathematical model	4.7.2.3	NA	NA	R	NA
Availability:	4.7.3				
Structure model	4.7.3.1	NA	NA	NA	R
Model adaptation	4.7.3.2	NA	NA	NA	R
Mathematical model	4.7.3.3	NA	NA	NA	R
Data sources:	4.8				
Reliability data	4.8.1	R	R	CR	R
Maintainability data	4.8.2	R	NA	R	R
Maintenance support data	4.8.3	R	NA	CR	R
Calculation principles	4.9	R	R	R	R
Prediction results	4.10	R	R	R	R

R = Required

CR = Conditionally required

NA = Not applicable

4. DETAIL REQUIREMENTS OF THE PRESENTATION

4.0 The requirements covered in 4.1 to 4.10 enlarge upon the specific requirements listed in 3.

4.1 Summary — The object of the prediction, main use conditions, maintenance support policy and the result shall be summarized. Any fundamental simplifying assumptions shall be stated.

4.2 Prediction Purpose — The aim of a prediction may vary, such as, for providing a basis for specification work, design analysis or planning or maintenance. It may also be to call attention to weak points in the hardware and in the maintenance organization and to suggest possible improvements.

The aim is to govern the choice of reliability measures, methods of analysis, data sources, kind and depths of presentation of results, etc.

Therefore, the purpose of the prediction and the relationship between the prediction and any other part of the reliability, maintainability and availability programme shall be clearly stated.

4.3 Prediction Object — Information needed to completely identify the object of the prediction shall be stated. This should, if applicable, include the following:

- a) System/equipment type, specification, including development status;
- b) Maintenance support policy; and
- c) Level of maintenance (in case of maintainability prediction).

Where prediction includes human performance and skill assumptions, these shall be properly described and quantified to permit proper measurement in system/equipment performance evaluation.

Relevant documented information, such as descriptions and diagrams, shall, as a minimum, be referenced or included.

4.4 Characteristics — The system/equipment reliability, maintainability and availability characteristic(s) which is (are) the final object of the prediction, shall be stated.

Definitions of the characteristic(s) shall be given in any one of the following ways:

- a) By reference to IS : 1885 (Part XXXIX) - 1979* and IS : 7690-1975†;
- b) Explicitly in the prediction report; and
- c) By reference to relevant system/equipment documents, such as specifications of reliability, maintainability and availability requirements.

4.5 Initial Conditions — Where possible all predictions should be based on predetermined requirements and conditions.

4.5.1 System/Equipment Functions — A system or equipment may be intended to function in many ways or to carry out sequences of functions. Any such function or sequence of functions covered by the prediction shall be stated. Any function or equipment excluded from the prediction and the reason for its exclusion shall also be stated.

4.5.2 Failure Definitions — The reliability and availability characteristics are generally dependent on the failure definitions used.

The applicable definition of failures of the system/equipment shall therefore be stated. Failure definition shall also be stated for all items for which quantitative data are used in the prediction models.

4.5.3 Quality/Reliability Programme — The quality, properties and maturity of the system/equipment shall be stated, as applicable, for instance, in terms of the following:

- a) System/equipment burn-in,
- b) Reference to quality/reliability programme of system/equipment and components, and
- c) Component screening.

Any assumption regarding reliability or maintainability growth shall be stated.

4.5.4 Environmental Conditions — The environmental conditions, for which the prediction is performed, shall be stated. The conditions should, if

*Electrotechnical vocabulary : Part XXXIX Reliability of electronic and electrical items (*first revision*).

†Mathematical guide to the terms and definitions for reliability of electronic equipment and components (or parts) used therein.

possible, be stated with reference to degrees of severity of applicable environmental factors in accordance with IS : 9000 (Part I)-1977*.

In some cases, it may also be pertinent to make predictions for several different combinations of environmental factors and severities, covering, for instance, storage, transport and operation.

4.5.5 Operational Conditions — The operational conditions for which the prediction is performed shall be stated. At least the following categories of conditions shall be considered:

- a) Input and output loading, including type, intensity and duration of equipment functions used;
- b) Actual handling of the system or equipment; and
- c) Operational support, such as supply of power, coolants, consumables.

4.5.6 Definition of Maintenance Actions — It shall be stated on which system/equipment complexity level corrective maintenance shall be performed, such as failure localization of replaceable units or failure localization down to component level. Such decisions will be derived from a maintenance analysis based on actual operation failure modes, modularization and test functions.

As a result a list of maintenance actions shall be given. The maintainability analysis shall be referenced or given in the prediction report.

The tasks included in a completed maintenance action, for example, failure detection, failure localization, (scheduled) exchange of unit/component, functional check-out shall therefore be stated.

4.5.7 Preventive Maintenance Conditions — The preventive maintenance conditions for which the prediction is performed shall be stated in the form of:

- a) Categories and qualities of preventive maintenance resources (see 4.5.8);
- b) Categories of preventive maintenance actions;
- c) Criteria covering the scheduling of preventive maintenance, for example, fixed interval between actions, degree of wear-out; and
- d) effects on system readiness for operation.

*Basic environmental testing procedures for electronic and electrical items: Part I General.

4.5.8 Corrective Maintenance Conditions — Categories and qualities of corrective maintenance resources shall be defined. This may include the following:

- a) Replacement units,
- b) Spare components,
- c) Test equipment,
- d) Tools,
- e) Test programmes,
- f) Documentation, and
- g) Personnel.

4.5.9 Maintenance Support Conditions — Availability and certain reliability and maintainability characteristics are generally dependent on the amount of resources and on the organization of maintenance support.

The maintenance support conditions for which the prediction is performed shall be stated, for instance, probability of spares shortage, availability of repair men.

4.6 Analysis

4.6.1 Reliability Structure Analysis — The reliability structure analysis gives a reliability model. This model is a graphical description of the equipment.

The chosen methods of analysis shall be stated. The reason for the choice should also be given.

4.6.2 Stress Analysis — Principles and procedures used to determine values of all relevant stress parameters shall be stated.

4.6.3 Maintainability Analysis — All tasks, sub-tasks and sequences of tasks necessary to perform each maintenance action shall be stated.

4.6.4 Maintenance Support Analysis — All factors which influence the ability to perform required maintenance (corrective or preventive) shall be stated. Such factors may be technical, personnel and administrative resources, for instance, rules for stocking and replenishment of spare components.

4.7 Models

4.7.1 Reliability

4.7.1.1 Structure model — A reliability model shall be given together with the justification, assumption and relevancy for selection. The

referred models are either block diagrams, failure trees, state diagrams or suitable combinations.

Graphs used shall be accompanied by sufficient information needed to interrelate the items of the reliability model, both with the system/equipment parts and with the applied mathematical model relevant to the reliability characteristics.

The significance of symbols used for the graphical description of the reliability model shall be stated.

4.7.1.2 Model adaptation — All assumptions, simplifications and approximations made when transforming the structure model into the corresponding mathematical model shall be given. Particularly any dependence on maintenance support conditions or maintainability and availability properties shall be stated, for instance, maintainability properties of redundant units or degree of preventive maintenance.

4.7.1.3 Mathematical model — The mathematical model used for each reliability characteristic and the derivation of applied formulae shall be stated or referenced.

If the reliability prediction is performed by a procedure which proceeds stepwise through several functional levels of the system/equipment the mathematical models used shall be presented separately for each reliability characteristic.

4.7.2 Maintainability

4.7.2.1 Structure model — A maintainability model shall be given together with the justification, assumption and relevancy for selection. The model may be of the type listing of maintenance tasks and sub-tasks or maintenance actions, flow charts, sequence diagrams.

The models used shall be accompanied by sufficient information needed to interrelate the items of the maintainability model both with the system/equipment parts and maintenance conditions and with the applied mathematical model relevant to the maintainability characteristic.

4.7.2.2 Model adaptation — All assumptions, simplifications and approximations made when transforming the structure model into the corresponding mathematical model shall be given. In particular, any dependence on reliability characteristic and availability properties shall be stated, for instance, failure rate of units/components for estimating frequency of maintenance tasks or for calculating system maintainability parameters in redundant designs.

4.7.2.3 Mathematical model — The mathematical model used for each maintainability characteristic and the derivation of applied formulae shall be stated.

If the maintainability prediction is performed by a procedure which proceeds stepwise through several functional levels of the system/equipment the mathematical models used shall be presented separately for each level and for each maintainability characteristic.

4.7.3 Availability

4.7.3.1 Structure model — The availability structure model shall be given either by reference to reliability and maintainability models or separately by means of, for instance, block diagrams, failure trees, state diagrams or suitable combinations.

4.7.3.2 Model adaptation — All assumptions, simplifications and approximations made when transforming the structure model into the corresponding mathematical model shall be given.

4.7.3.3 Mathematical model — The mathematical model used for each availability characteristic and the derivation of applied formulae shall be stated.

If the availability prediction is performed by a procedure which proceeds stepwise through several functional levels of the system/equipment the mathematical models used shall be presented separately for each level and for each availability characteristic.

4.8 Data Sources — The source(s) of the data used shall be stated together with available relevant information regarding how the data was collected and processed.

Any statistical treatment of the data in order to adapt them to the mathematical model(s) shall be described and justified.

4.8.1 Reliability Data — Reliability data used, such as component failure rates or mean times between failures at unit level, shall be stated or referenced.

4.8.2 Maintainability Data — Maintainability data used, such as mean active repair times at different levels, shall be stated or referenced.

4.8.3 Maintenance Support Data — Maintenance support data used, such as numbers of repair men and spare parts, shall be stated either directly or in terms of probabilities. In cases where these data may be expressed in a few figures, for instance, probability of having a replacement unit available at the time of failure, it may be convenient to state them in connection with the maintenance support conditions or referenced.

4.9 Calculation Principles — Approximations and methods of numerical calculations used for the intermediate and final results shall be stated.

4.10 Prediction Results — The numerical results, other conclusions and discussion of uncertainties shall be clearly presented in accordance with the purpose of the prediction and the chosen reliability, availability and maintainability characteristics.

The applicability of the prediction results to other environmental, operational and maintenance conditions may be pointed out.

A P P E N D I X A

(Clause 0.2)

PREDICTION ACTIVITIES

A-0. GENERAL

A-0.1 In order to clarify the principle of presentation, a flow of prediction activities is presented. This procedure is not to be considered as a standard.

A-0.2 A prediction of reliability, maintainability and availability characteristics of system/equipment may generally be seen as a multistage model building. From these models conclusions are drawn regarding the characteristics of the actual system/equipment. This modelling may usually be done in many different ways and with possibly quite different final results.

Generally the procedure follows six different steps (*see also* Fig. 1). By going backwards in the flow-chart from the desired result(s) the required activities, data sources, intermediate results and input conditions may be derived.

A-1. DEFINITION OF CONDITIONS

A-1.1 Collection of information on environmental, operational and maintenance conditions, etc, and system/equipment functions.

A-2. ANALYSIS

A-2.1 An analysis is made to determine:

- a) the structure of the system/equipment,
- b) the stresses applied to the system/equipment and its parts,
- c) the maintainability properties of the system/equipment, and
- d) the properties of the maintenance support.

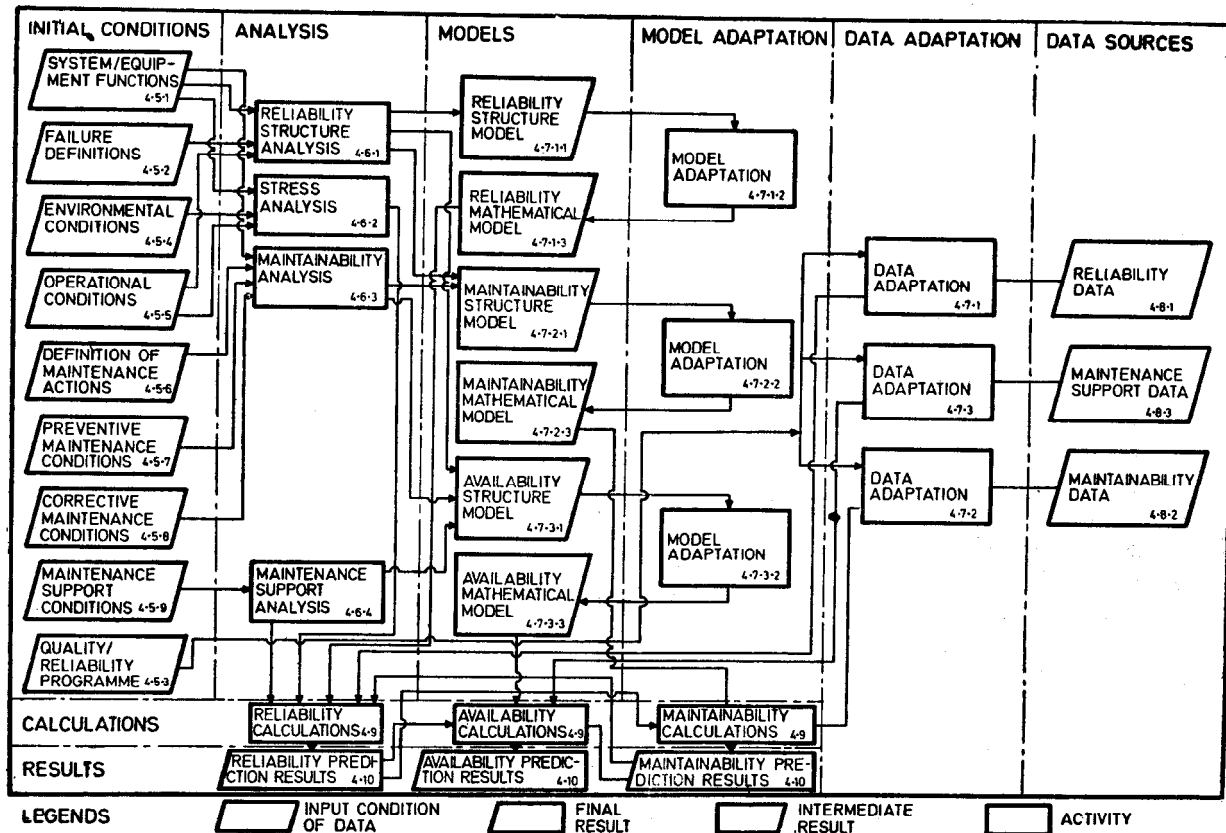


FIG. 1 RELIABILITY, MAINTAINABILITY AND AVAILABILITY PREDICTION, PROCEDURAL FLOW

A-2.1.1 Based on the analysis models are built for:

- a) the reliability structure,
- b) the maintainability structure, and
- c) the availability structure.

A-3. MODEL ADAPTATION

A-3.1 Considering the accuracy required, the purpose of the prediction and available probabilistic modelling tools, mathematical models for reliability, maintainability and availability are chosen.

A-4. DATA ACQUISITION

A-4.1 Data sources for reliability, maintainability and maintenance support are chosen. Data from the sources are then adapted to the mathematical models.

A-5. CALCULATIONS

A-5.1 Computational means with adequate accuracy are chosen and the actual calculations performed.

A-6. REPORT PREPARATION

INDIAN STANDARDS

ON

RELIABILITY OF ELECTRONIC AND ELECTRICAL COMPONENTS AND EQUIPMENT

IS :

- 1885 (Part XXXIX)-1979 Electrotechnical vocabulary : Part XXXIX Reliability of electronic and electrical items (*first revision*)
- 2612-1965 Recommendation for type approval and sampling procedures for electronic components
- 7354 Guide on reliability of electronic and electrical items:
(Part I)-1975 Preliminary reliability considerations
(Part II)-1975 Managerial aspects of reliability
(Part III)-1975 Presentation of reliability data on electronic and electrical components (or parts)
(Part IV)-1974 Collection of reliability, availability and maintainability data from field performance
(Part V)-1975 Inclusion of lot-by-lot and periodic inspection procedures in specifications for electronic and electrical components (or parts)
(Part VI)-1975 Inclusion of reliability clauses into the specifications for components (or parts)
- 7690-1975 Mathematical guide to the terms and definitions for reliability of electronic equipment and components (or parts) used therein
- 8161 Guide for equipment reliability testing:
(Part I)-1976 Principles and procedures
(Part VII)-1977 Compliance test plans for failure rate and mean time between failures assuming constant failure rate
(Part V)-1981 Compliance test plans for success ratio
- 9185 Endurance (life) test for electronic and electrical components:
(Part I)-1979 Thermal endurance
(Part II)-1979 Mechanical endurance
- 9186-1979 Guide for screening of electronic and electrical items
- 9692 (Part I)-1980 Guide on maintainability of equipment: Introduction to maintainability
(Part II)-1980 Maintainability requirements in specifications and contracts
(Part III)-1981 Maintainability programme

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